AUTOMATED PORTFOLIO MANAGEMENT SYSTEM

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Partial Fulfillment of the Requirements
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Bachelor of Technology

in

COMPUTER SCIENCE AND ENGINEERING

by

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to

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DECLARATION

We, **Partha Pratim Biswas (Roll No: 2019BCS0071), Ringriangsuiyang (Roll No: 2019BCS0023), Bande Akhil Sai (Roll No: 2019BCS0048), and Chandrima Meloth Jayaram (Roll No: 2019BCS0011)**, hereby declare that this report entitled **"Automated Portfolio Management System"** submitted to Indian Institute of Information Technology Kottayam towards the partial requirement of **Bachelor of Technology** in **Computer Science Engineering** is an original work carried out by us under the supervision of **Dr. Lidiya Lilly Thampi** and has not formed the basis for the award of any degree or diploma, in this or any other institution or university. We have sincerely tried to uphold academic ethics and honesty. Whenever an external information or statement or result is used then, that has been duly acknowledged and cited.

Kottayam - 686635
November 2022

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CERTIFICATE

This is to certify that the work contained in this project report entitled **"AUTOMATED PORTFOLIO MANAGEMENT SYSTEM"** submitted by **Partha Pratim Biswas (Roll No: 2019BCS0071), Ringriangsuiyang (Roll No: 2019BCS0023), Bande Akhil Sai (Roll No: 2019BCS0048) and Chandrima Meloth Jayaram (Roll No: 2019BCS0011)** to Indian Institute of Information Technology Kottayam towards partial requirement of **Bachelor of Technology** in **IIIT Kottayam** has been carried out by them under my supervision and that it has not been submitted elsewhere for the award of any degree.

Kottayam - 686635
November 2022

Dr. Lidiya Lilly Thampi
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ABSTRACT

The aim is to build an automated system that would be capable of managing a given portfolio without subjecting it to major risk factors, keeping in strict discretion that saving money is more important than making money. The focus would be on catching small and quick trending movements of the market, intended to get in and out of the markets in a few days to a few weeks. Capital allocation and trade management theories implemented here make the strategy highly active and aggressive compared to other typical positional trading styles.

The future is unknown and uncertain, but there are still ways of operating in the Stock Market using a good enough Trading Strategy. Further enhancements can be made to this using Machine Learning models to make calculated predictions. Long Short-Term Memory (LSTM) is among the most popular Deep Learning Models used today for such purposes and is also the one that we have used.

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Chapter 1

Introduction

First things first, it is important to understand that trading is not as simple as people make it sound or as shown in those annoyingly frequent TV and YouTube advertisements. To trade is easy, anyone can do that, but to be consistently profitable is a different game altogether. Understanding what a system is, what a strategy is, and most importantly if it is feasible to code is a really big deal. Not every strategy can be coded, so being smart about it is important.

Trading systems are majorly of two kinds - Systematic and Discretionary. **Discretionary** is when a person analyzes the charts and makes decisions based on his / her cognition. **Systematic** on the other hand is something that is fairly simple to implement with simple logic backed up with proper back-tested data. However what is common between the two is that both work on repeating patterns reflecting specific retail psychology, some of which are easy to plot and some are hard. In other words, some are programmable and some are not.

These patterns could be anything logical such as certain market structures being formed over and over again, certain indicators/oscillators showing similar behavioral patterns over time, again and again, similar market behavior near important psychological levels, and so on.

One such pattern is break of structure. Meaning that trades will get executed upon market crossing (also referred to as breaking) a specific structure or level. In order to make sure that it is easy to code, we tried to stick with Psychological Areas of Interest such as Weekly Highs & Lows, Monthly Highs & Lows, and so on.

Chapter 2
Literature Review

The area of predictive analytics is receiving tremendous interest from researchers across the globe, especially the prediction of non-stationary time-series data such as stock data. Stock price prediction is a very challenging task as it is highly volatile, nonlinear, and dynamic. Neural networks have been widely used for forecasting time series.

Ghosh et al. [1] proposed an LSTM model to predict the stock prices of various Indian banks; State Bank of India (SBI), HDFC Bank, and ICICI Bank. The Data was collected from the official BSE website. 2 months of data were taken as training data. The model predicted future values for three months, six months, 1, and 3 years intervals. The model included 3 LSTM layers and a dense layer with a linear activation function for the model to be the finest. The error values over the period kept on decreasing significantly. The average error for one month was around 232.6, and that for 3 years was 0.89. The experiment proved that LSTM thrived on prediction on a much more extensive range of data. **Asutosh Nayak [2]** predicted the stock prices of General Electric (G.E.) using the LSTM algorithm. There were 14 060 items, each representing some stock-related feature of the company on a particular day. Time steps were taken to be 60, so two months of data were looked into to predict the next day's price. LSTM provided astonishing results. The author chose LSTM over 100 other combinations as it worked the best out of all the others and fulfilled the purpose of the study.

Fischer et al. [3] used LSTM for out-of-sample prediction of financial time series. It was found to outperform logistic regression, DNN, and RAF. A short-term trading strategy was devised based on the LSTM outputs. **Hiransha et al. [4]** compared LSTM, RNN, CNN, and MLP with linear and non-linear regression models. The networks were trained with one company from NSE and then tested on five companies from NSE and NYSE. LSTM was found to outperform other models. **Karmiani et al. [5]** compared LSTM with SVM, backpropagation, and Kalman filter for the stock market for different numbers of epochs varying from 10 to 100. LSTM was found to have high accuracy and low variance. **Lu et al. [6]** created a CNN-LSTM model to predict the stock market. Networks like MLP, CNN, RNN, LSTM, and CNN–RNN were employed for comparative analysis to make the CNN-LSTM algorithm more efficient and accurate. Price movements of The Shanghai Composite Index were taken as experimental data. The stock data used was taken from July 1991 to August 2020, including 7127 trading days. For historical data, opening and closing prices, highest and lowest prices, turnover ups and downs, volume, and change were considered. Experiments show that the CNN-LSTM model has the most accurate depiction of stock price movements than MLP, CNN, RNN, LSTM, and CNN–RNN. CNN-LSTM model improved by 2.2%, 0.6%, 0.5%, and 0.2% respectively.

Zou et al. [7] used the daily prices and volumes of the top 10 S and P 500 stocks. The statistics were from the year 2004 to 2013. The Data was split in the ratio of 70:15:15 for training, development, and testing data, respectively. To obtain the best model, four models: ARIMA, LSTM, Stacked-LSTM, and Attention-LSTM. MSE was considered for model assessment. Out of the four models, Attention-LSTM proved to be superior among all; the model can predict the financial time series much better due to the long-term dependence of time series. **Pramod et al. [8]** Developed a stock data predictor using the LSTM technique. The model considers a company's historical equity share prices and applies the LSTM model to predict price movements. The historical Data consists of opening, closing price, day low, day high, trading date, turnover, and total quantity traded. The model was used to predict price movements of the TATA

MOTORS share price. It efficiently achieved an accuracy of 96, LSTM units were employed, and an epoch batch size of 50. The results were clear-cut. The model showed an astonishing 0.0024 minimum loss rate and moved just along the actual value of the share price. On the 300th day, the actual opening price was 172 INR, while the predicted price of the model amounted to 166 INR.

Table 2.1 Summarized studies for Stock Market prediction

Models	**Dataset**	**Method**	**Conclusion**	**Reference**
LSTM, other models like SVM, CNN, NFNN, and Multiple Pipeline models were used to compare results.	S and P 500 stock prices were taken as prediction data. Data was taken for 20 years, from Jan 30, 1999, to Jan 30, 2019.	Multiple LSTMs were taken to learn the time dependencies of features of different time scales. All the information was combined to predict the closing price in the future	The LSTM model proved to be better than other models due to its impressive capability of efficiently processing the data. The model had an accuracy of 74.55% over one month.	**Hao et al. [9]**
Comparison between ANN and LSTM. To compare results, RMSE was used.	Dixon Hughes, Cooper Tire and Rubber, PNC financial, CitiGroup, Alcoa Corp.	The LSTM model had 1 Input layer having five neurons, 'n' hidden layers, and one output layer.	LSTM had a much better prediction accuracy. For every company, RMSE was lower when predicted through LSTM and slightly higher through ANN.	**Nandakumar et al. [10]**
LSTM, MLP, SVM.	Eleven stocks were selected from the Brazilian stock series of 2016 with total data of 250 days. The majority of these stocks were part of the main Brazilian Index (BOVA11) in 2016.	The figures were divided into 166 days of training data and 84 days of test data. The LSTM model contained four layers with 8, 4, and 2 LSTM units, respectively. The last layer was the output layer	LSTM stood out of all the models, although the gap was not very large due to the limited data. If the data had been more like 2000 days, LSTM would have been the winner with a huge margin.	**Mesquita et al. [11]**
MLP, LSTM, CNN	CSI300 from China, S and P 500, Nikkei225 from Tokyo. All the stock data is selected from July 2008 to September 2016. 90% of the Data was used as training data, while 10% was used as test data.	The LSTM model had 140 hidden layers. Each model was predicted using MAPE, RMSE, and R.	The LSTM model performed well in predicting. MLP performed the worst.	**Gao et al. [12]**

Chapter 3
Methodology

3.1 Architectures

3.1.1 - Trading System

The System will work on the already shortlisted stocks. For each stock in the list, Historical Data specifically the High and Low of the previous two weeks will be used to generate levels such as Entries, Targets 1 & 2, Fixed Stop Losses, and Trailing Stop Losses, and finally the Buy and Sell signals accordingly in the later phases of the program. These levels are necessary for the implementation of the trading strategy which will be discussed in section 3.3.

After the signals are generated they are validated through the ML system and depending upon the results further actions are taken in terms of Order Placement, Position Sizing, etc. Timely booking of profits and losses is also performed in accordance with the active monitoring of the stock prices. (Fig. 3.1.1)

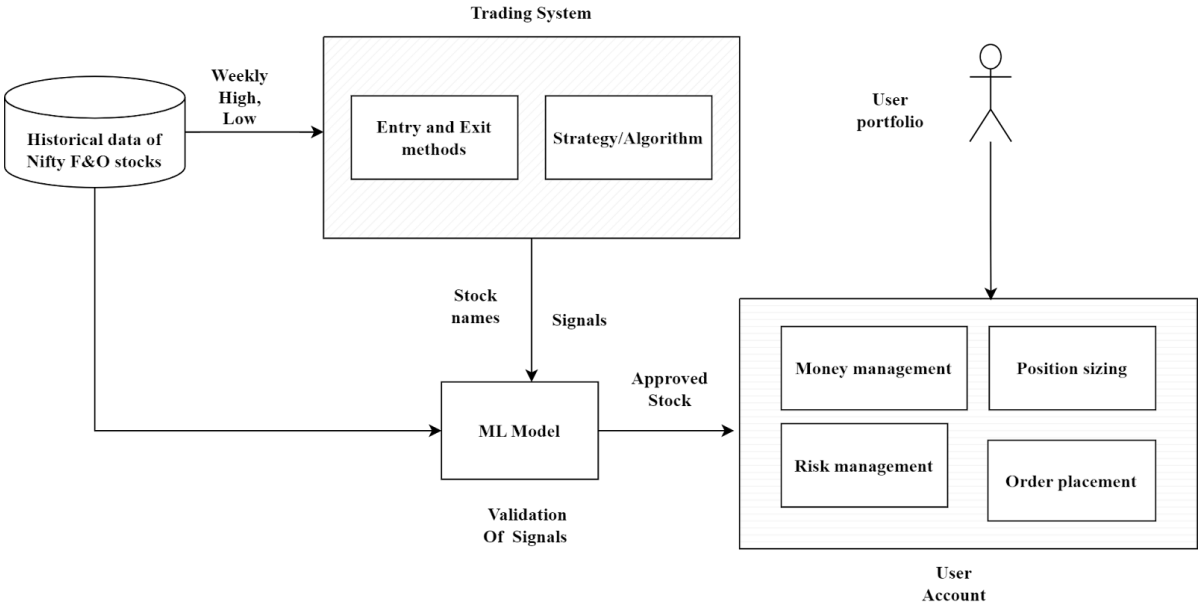

Fig. 3.1.1 - Trading System

3.1.2 - Trading Strategy

Here, we will see the generation of levels, generation of Buy and Sell signals at the appropriate times, and monitoring the trades actively to square off all the positions as and when necessary. Most importantly it is assigned the responsibility to take actions upon the generated levels when the price crosses / breaks it. It calculates the quantity as per the risk appetite of the user, does the transaction for the same quantity of stocks, and actively keeps on squaring off fractions of the original quantity upon different target levels. The Stop Loss levels also keep on getting updated every week so as to safeguard some amount of profits at certain levels, also known as Trailing of Stop Loss.

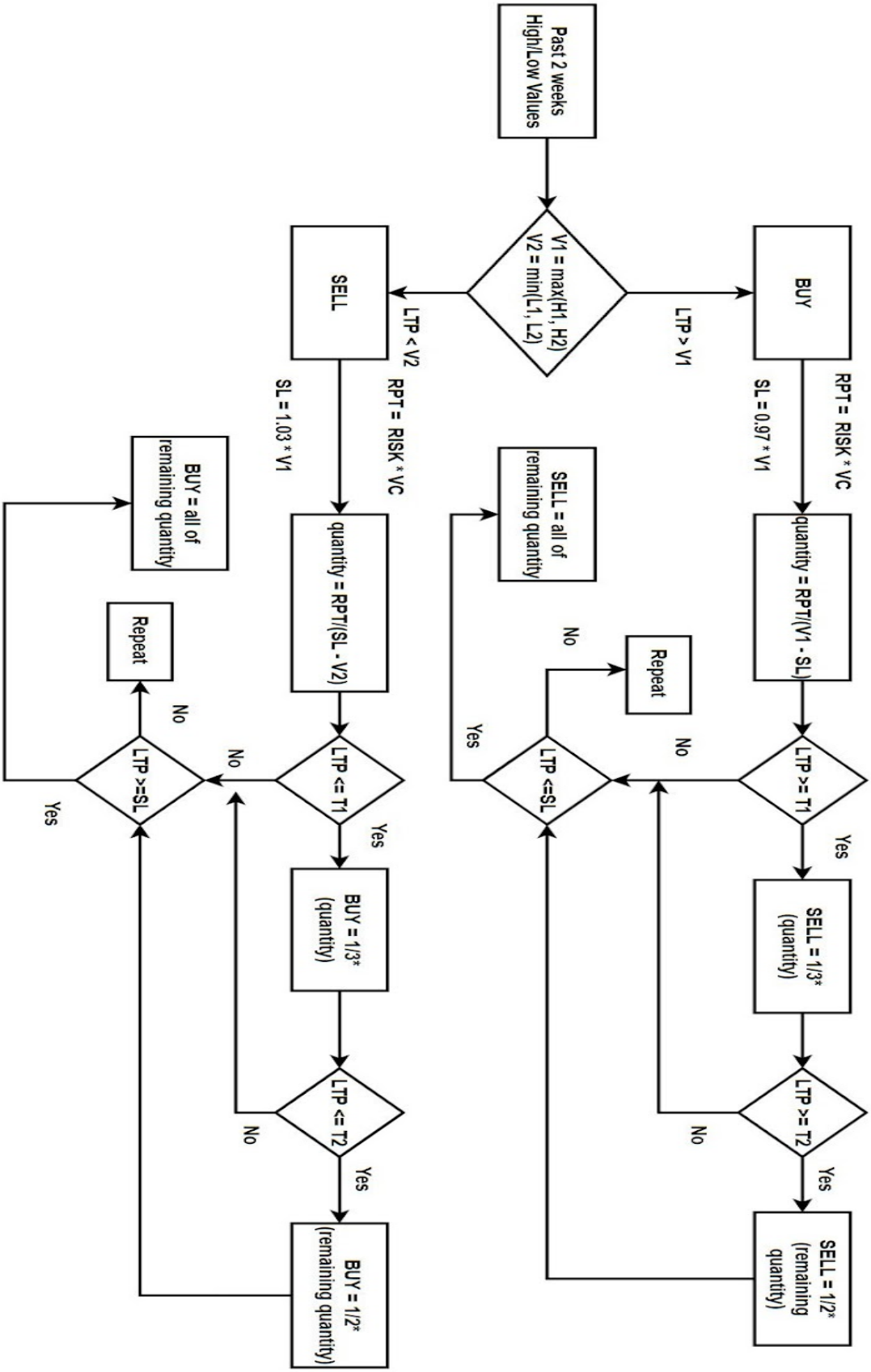

Fig. 3.1.2 - Trading Strategy

3.2 Stock Shortlisting Method

Out of all the thousands of stocks that are listed in the National Stock Exchange, we would be using only those that are listed inside the Futures & Options segment. Primarily, FNO stocks have relatively better Liquidity which means that getting in and out would have a lesser impact on Cost. And also, trading in the Futures segment gives access to a 5 times Leverage which otherwise is not available while trading in the Equity segment.

3.3 Trading System

3.3.1 - Entry Methods

3.3.1.1 - Algorithm

1. The last two weeks' Highs and Lows are noted. The maximum of the two Highs and minimum of the two Lows are considered Entry levels for Buy and Sell respectively.
2. When the price breaks the Entry Level for Buy on the upper side, it is a signal for Buying. Similarly, when the price breaks the Entry Level for Sell on the lower side, it is a signal for Selling.
3. The immediate levels that are calculated next are the Target Levels and Stop Loss Levels.
4. The appropriate quantity as per the Risk Profile of the Portfolio is calculated based on the difference between the Entry Level and the Stop Loss level and the system is now ready to punch the order into the Broker platform once the ML system validates it.

3.3.1.2 - ML Model

1. The ML model tries to predict the chances of hitting the Stop Loss in a particular trade. Hitting the Stop Loss is equivalent to the price reaching a certain level in the near future, a level that the ML system will try to predict.
2. If the chances are high enough, we avoid the trade. Else the trade is good to go, meaning that the orders get punched into the Broker platform.

3.3.2 - Exit Methods

1. Target Levels 1 and 2 remain intact as per the rules defined in the Entry Method.
2. The SL is updated every week based on the new price data.
3. For every change in price, it checks if either of the Targets or SL is hit.
4. On every Target being achieved, certain portions of the quantity are booked and the remaining is left to run. And all quantities are booked upon hitting the SL.
5. This is performed as follows -
    a. On hitting Target 1 @ 3% Profit, 33% of the Total Quantity is booked.
    b. On hitting Target 2 @ 6% Profit, 50% of the Remaining Quantity is booked.
    c. On hitting the SL, either the Fixed SL @ 3% or Trailed SL as per the system, 100% of the Remaining Quantity is booked.

3.3.3 - Risk & Money Management

1. Maximum Risk Per Trade is assigned to 1% of the total Allocated Capital. That means that in case a trade hits the SL, the loss encountered in that trade would not be more than 1% of the Allocated Capital.
2. Maximum Stop Loss is set at 3% of Stock Price, and Minimum Target is set at 3% of Stock Price. Hence, while winning we win at least 3%, and while losing we lose at most 3%.
3. Position Sizing i.e. Quantity is calculated as per the following formula:

$$Quantity = RPT \times Total\ Capital / |Entry - Stop\ Loss| \quad \textbf{..3.1}$$

4. The profitability of a system depends on two major factors. Win Rate and Risk to Reward Ratio.

$$Win\ Rate = Total\ Winning\ Trades / Total\ Trades \times 100 \quad \textbf{..3.2}$$

$$R{:}R = Average\ Profit\ on\ Winning\ Trades / Average\ Loss\ on\ Losing\ Trades \quad \textbf{..3.3}$$

5. The Win Rate and Risk to Reward Ratio are inversely proportional, hence finding a sweet spot between the two became important.
6. In our system, profitability was ensured by keeping the Risk to Reward Ratio high enough. The exact values calculated for all the 194 FNO stocks for the last 5 years are as follows -
    a. Average Win Rate = 45.86%
    b. Average Risk : Reward = 1 : 2.16

Chapter 4
Demonstration and Result

4.1 Demonstration

4.1.1 - Winning Trades

4.1.1.1 - Buy Side

Fig. 4.1. Laurus Labs LTD

Fig. 4.2. Rain Industries LTD

Fig. 4.3. SRF LTD

4.1.1.1 - Sell Side

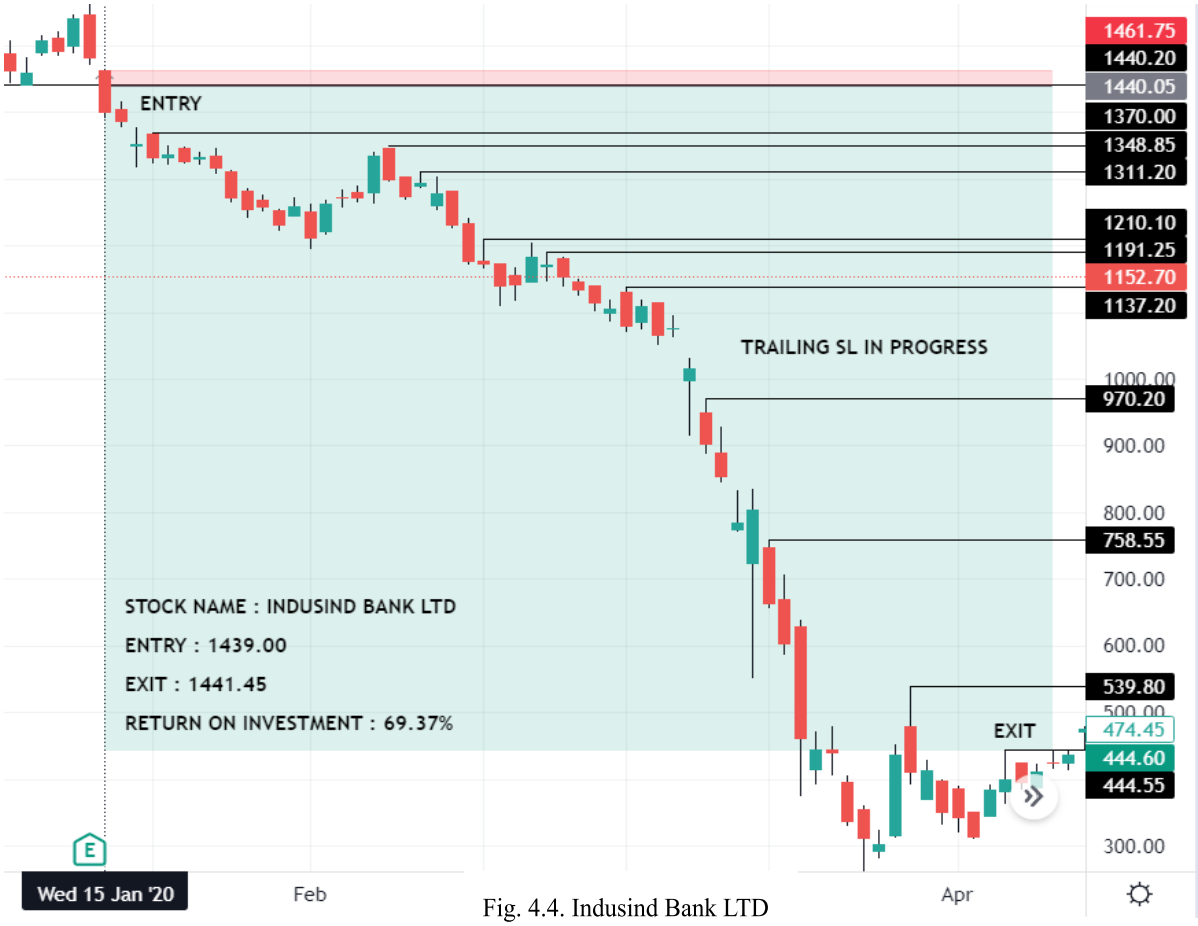

Fig. 4.4. Indusind Bank LTD

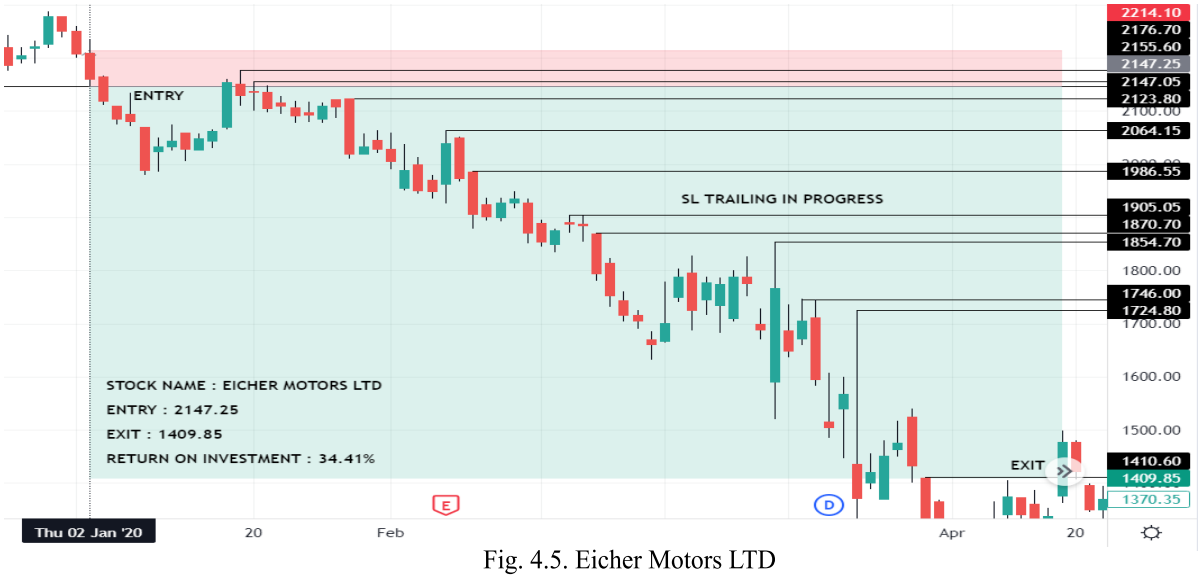

Fig. 4.5. Eicher Motors LTD

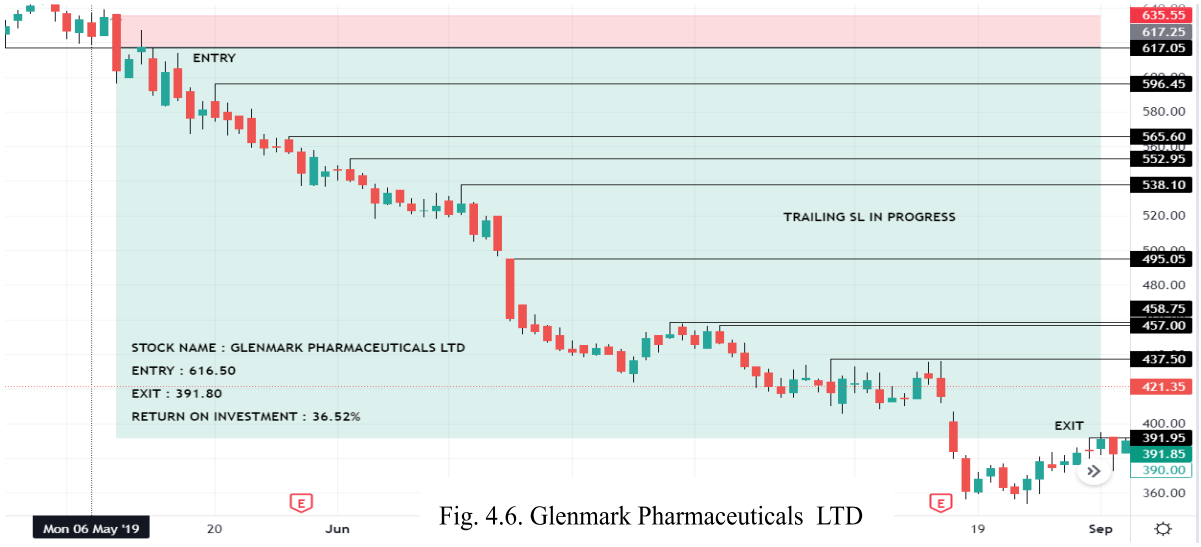

Fig. 4.6. Glenmark Pharmaceuticals LTD

4.1.2 - Losing Trades

4.1.2.1 - Buy Side

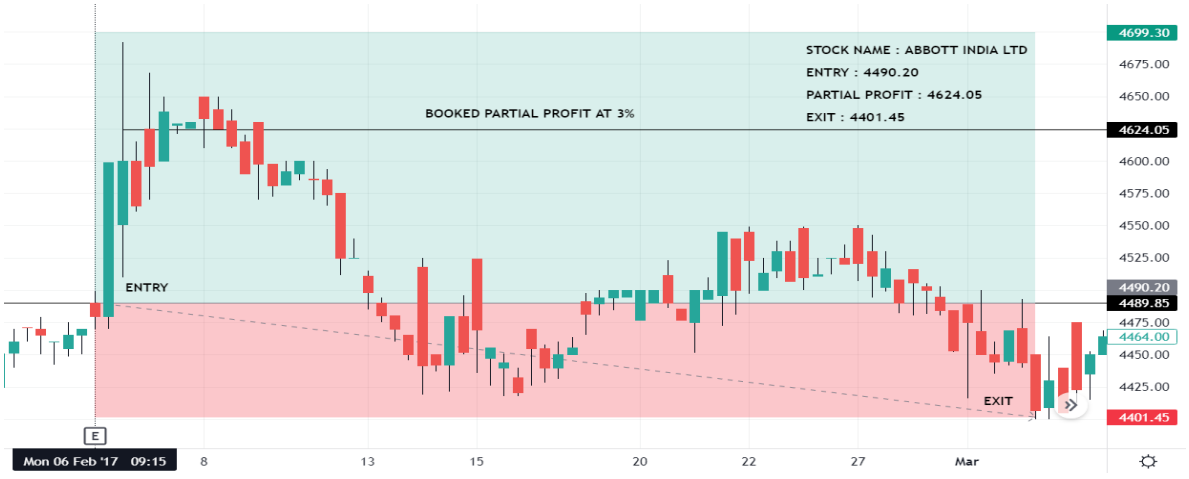

Fig. 4.7. Abbott India LTD

Fig. 4.8. Oracle Fin Service

4.1.2.2 - Sell Side

Fig. 4.9. Wipro LTD

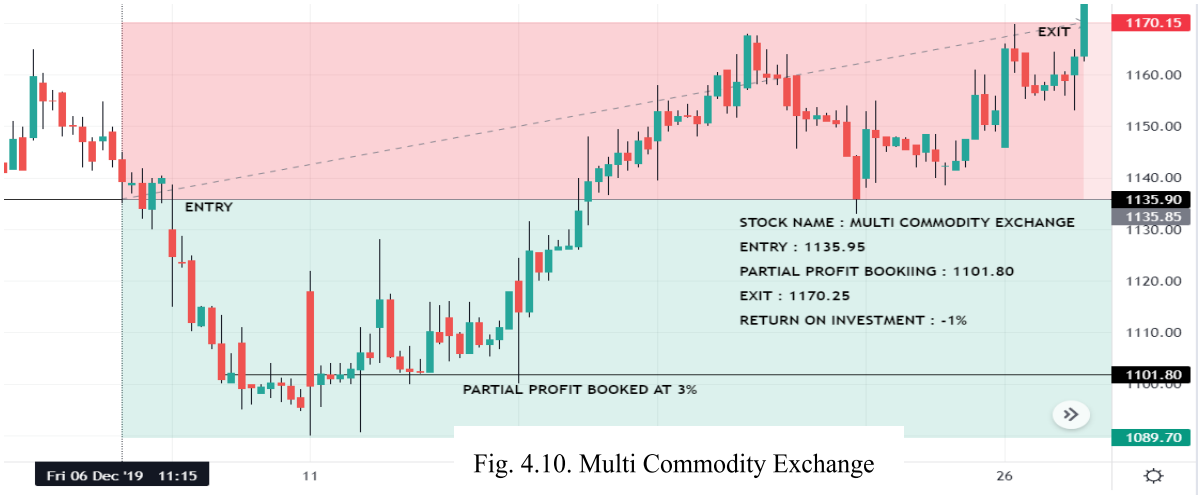

Fig. 4.10. Multi Commodity Exchange

4.1.3 - LSTM

1. Overview

We got the historical stock price data from Yahoo Finance. The dataset consists of High, Low, Open, and Close prices as well as the Traded Volume for each day. After collecting data, the next step is to preprocess the data. But since our dataset is already preprocessed, we just need to fetch the data that we would require to train our model. Training is the most important part of Machine Learning. We have divided the dataset into a ratio of 80:20 for training and testing the model respectively. The next step is to divide the training data into batches of fixed size and feed the data into the LSTM model.

2. LSTM Architecture

LSTM is a type of recurrent neural network (RNN). RNNs are a powerful type of artificial neural network that can internally maintain memory of the input. This makes them particularly suited for solving problems involving sequential data like a time series. However, RNNs frequently suffer from a problem called vanishing gradient which leads to the model learning becoming too slow or stopping altogether. LSTMs have longer memories and can learn from inputs that are separated from each other by long time lags.

An LSTM has three gates: an input gate which determines whether or not to let the new input in, a forget gate which deletes information that is not important and an output gate which decides what information to output. These three gates are analog gates based on the sigmoid function which works in the range of 0 to 1. These three sigmoid gates can be seen below. A horizontal line that can be seen running through the cell represents the cell state.

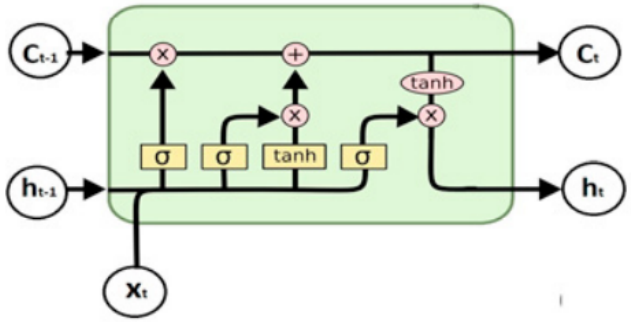

Fig. 4.11. LSTM Architecture

3. Evaluating the Model

Table 4.1 Current parameters implemented in the Model

Dataset Used	Historical Daily Stock Prices of the Stocks for the last 5 Years
Tested Stocks	TCS, WIPRO, ICICIBANK, NESTLEIND, and RELIANCE
Total Dataset Per Stock	1233 Days Closing Prices
Training Data Length	987 Closing Prices (80% of the Dataset)
Testing Data Length	246 Closing Prices (20% of the Dataset)
Training Sequence Length	60
Epoch	100
Number of Layers	2
Number of Network Units in each Layer	100
Number of Dense Layers	2

4. Hyperparameter Tuning

Table. 4.2 Parameters in different variants

Model	**Number of Layers**	**Number of Network Units in each Layer**	**Number of Dense Layers**	**Batch size**	**Dropout layers**
Base model	2	100	2	1	NA
Variant 1	2	50	2	1	NA
Variant 2	2	50	2	32	NA
Variant 3	4	50	2	32	4
Variant 4	4	50	1	32	4

Table 4.3 Comparison of Different Variants With Base Model

Model	RMSE VALUES				
	TCS	**WIPRO**	**ICICIBANK**	**NESTLEIND**	**RELIANCE**
Base Model (Before Hyperparameter Tuning)	15.848266849672891	1.1158877737153836	12.149792120708682	44.29713104992378	2.791133229325457
Variant 1	39.298116048177086	1.5954256135273754	12.037573837652438	34.05956038808435	0.6980060360295985
Variant 2	23.865453972251424	2.6374985125354896	10.452197341852943	96.38651297514 3582	0.7849516578741254
Variant 3	8.946689264561103	0.3100153605143 2294	2.692625278379859	12.55351840383 6382	1.4720276623237423
Variant 4	18.125489655523874	2.3148621349799923	4.230424152157 1712	64.97478404471545	1.3092739446376398

4.2 Results

4.2.1 Back Tested Report

4.2.1.1 Trading Strategy

Table 4.4 Back Tested Report

STOCK NAME	PROFIT IN PERCENTAGE					PERFORMANCE METRICS					
	2017	2018	2019	2020	2021	TOTAL TRADES	WIN RATE	AVERAGE PROFIT IN %	AVERAGE LOSS IN %	AVERAGE R:R	TOTAL PROFIT
VODAFONE IDEA LIMITED	188.95	128.5	257.9	378.95	270.65	73	58.9	6.9	1.93	3.58	1224.95%
INDIABULLS HSG FIN LTD	181.25	142.8	269	368	109	78	67.95	5.07	2.1	2.41	1070.05%
TATA MOTORS LIMITED	68.1	135.1	168.85	237.35	234.2	71	56.34	6.32	2.28	2.77	843.60%
ADANI ENTERPRISES LIMITED	99.6	130.65	122.55	232.65	255.3	82	54.88	6.11	2.08	2.94	840.75%
L&T FINANCE HOLDINGS LTD	141.95	158.7	188.65	240.7	98.7	68	61.76	5.36	2	2.68	828.70%
HINDUSTAN COPPER LTD	-60.45	82.1	161.35	238.6	399.05	76	56.58	6.26	2.4	2.61	820.65%
PUNJAB NATIONAL BANK	184.5	145.05	92.05	293.4	105.3	72	58.33	5.42	2.07	2.62	820.30%
RAIN INDUSTRIES LIMITED	186.4	84.2	153.35	221.2	141.2	74	58.11	6.82	1.96	3.48	786.35%
GUJ NAR VAL FER & CHEM L	130.9	17.35	171.5	265.8	165	81	55.56	5.13	2.06	2.49	750.55%
INTELLECT DESIGN ARENA	105.15	4.85	74.75	450.85	92.9	79	44.3	7.64	2.37	3.22	728.50%
JINDAL STEEL & POWER LTD	102.85	105.95	102.1	321.45	93	87	50.57	5.76	1.99	2.89	725.35%
STATE BANK OF INDIA	120.6	89.9	182.8	164.5	162.75	65	56.92	5.54	2	2.77	720.55%
BHEL	144.75	4.2	149	234.75	149.55	72	56.94	5.26	2.29	2.30	682.25%
HINDUSTAN AERONAUTICS LTD	0	109.3	147	301.45	124.25	47	65.96	5.61	2.51	2.24	682.00%
FIRSTSOURCE SOLU. LTD.	86.9	134.95	50.35	248.55	156.15	84	54.76	4.56	1.95	2.34	676.90%
ADITYA BIRLA CAPITAL LTD.	26.7	185.9	104.5	295	47.95	65	55.38	5.38	1.93	2.79	660.05%
LAURUS LABS LIMITED	-57	-13.85	37.1	541.7	151.6	74	43.24	7.25	2.29	3.17	659.55%
TATA POWER CO LTD	26.7	106.9	120	225	173.8	69	60.87	4.85	2.41	2.01	652.40%
RBL BANK LIMITED	110.35	50.5	162.7	194.15	128	74	51.35	5.25	2	2.63	645.70%
DIXON TECHNO (INDIA) LTD	10.1	95.9	166.8	227.05	138.3	59	61.02	6.02	2.28	2.64	638.15%
STEEL AUTHORITY OF INDIA	40.7	140.55	96.7	166.55	172.4	78	56.41	5.46	2.22	2.46	616.90%
BHARAT ELECTRONICS LTD	62.55	137.9	198.75	220.05	-8.4	76	52.63	5.13	2.19	2.34	610.85%
HINDUSTAN PETROLEUM CORP	147.05	87.1	150.85	135	82.45	71	54.93	4.71	1.95	2.42	602.45%
BANK OF BARODA	12.5	92.55	155.65	176.2	153.9	77	49.35	5.56	2.34	2.38	590.80%
IDFC LIMITED	54.8	117.35	37.95	282.45	75.55	78	53.85	4.97	2.27	2.19	568.10%
BHARAT PETROLEUM CORP LT	88.5	64.3	139.65	164.85	108.55	75	57.33	4.24	1.87	2.27	565.85%
AU SMALL FINANCE BANK LTD	-7.95	96.35	-20.75	362.55	135.45	65	52.31	5.61	2.34	2.40	565.65%
IDFC FIRST BANK LIMITED	1.45	161.65	85.75	167.85	145.25	79	51.9	4.91	1.86	2.64	561.95%
PIRAMAL ENTERPRISES LTD	-11.2	147.8	167.7	172.4	83.65	79	45.57	5.45	1.94	2.81	560.35%
NATIONAL ALUMINIUM CO LTD	139.15	68.6	35.25	193.8	123.1	77	55.84	4.49	2.24	2.00	559.90%
PERSISTENT SYSTEMS LTD	70.9	91.3	-14.9	247.55	163.25	65	52.31	5.75	2.17	2.65	558.10%
REC LIMITED	189.95	119.75	107.45	130.85	5.3	73	57.53	4.44	2.17	2.05	553.30%
SHRIRAM TRANSPORT FIN CO.	3.5	180.25	8.6	266	93.75	83	54.22	4.41	2.16	2.04	552.10%
BIRLASOFT LIMITED	23.4	-20.7	151.7	341.3	53.5	79	51.9	5.29	2.16	2.45	549.20%
GLENMARK PHARMACEUTICALS	143.15	75.65	156.95	169.45	-0.75	76	42.11	6.31	2	3.16	544.45%
BANDHAN BANK LIMITED	0	117.9	63.95	301.8	57.9	55	50.91	6.03	2.05	2.94	541.55%
AUROBINDO PHARMA LTD	37.2	54.55	102	245.6	94.25	66	48.48	5.53	1.97	2.81	533.60%
RELIANCE INDUSTRIES LTD	90.6	61.55	132.85	141.8	98.2	68	54.41	4.68	2.19	2.14	525.00%
PVR LIMITED	80.15	101.7	13.25	288.75	35.85	67	52.24	5.22	2.36	2.21	519.70%
BAJAJ FINANCE LIMITED	111.8	114.05	44.95	193.55	47.05	70	42.86	6.55	2.2	2.98	511.40%
TITAN COMPANY LIMITED	83.3	72.25	104.6	119.95	129.25	72	48.61	5.19	2.2	2.36	509.35%
SAMVRDHNA MTHRSN INTL LTD	-2.95	-4.35	170.65	287.65	57.2	81	45.68	5.3	2.23	2.38	508.20%
ZEE ENTERTAINMENT ENT LTD	-108.8	47.45	155.7	207.45	200.25	79	53.16	4.27	2.11	2.02	502.05%
CANARA BANK	111.8	73.7	161.25	112.05	42.3	81	48.15	5.43	2.42	2.24	501.10%
INDIAN RAIL TOUR CORP LTD	0	0	9.95	199.5	288	28	50	9.16	2.08	4.40	497.45%
DLF LIMITED	160.85	129.55	88.1	32	76.8	71	50.7	5.6	2.26	2.48	487.30%
NAVIN FLUORINE INT. LTD	75.35	54.1	188.7	64.45	100.85	74	51.35	4.31	1.91	2.26	483.45%
GODREJ PROPERTIES LTD	38.05	126.95	54.25	122.65	139.45	69	46.38	5.91	2.39	2.47	481.35%
CAN FIN HOMES LTD	108.4	5.7	51.1	164.35	147	84	45.24	4.84	2.11	2.29	476.55%
NMDC LTD.	102	40.95	155.05	98.75	77.25	73	50.68	5.07	2.22	2.28	474.00%
DELTA CORP LIMITED	49.55	56.85	136.75	129.2	99.35	89	41.57	5.76	2.16	2.67	471.70%
INDUSIND BANK LIMITED	18.7	25	73.55	279.3	71.85	77	49.35	4.58	2.12	2.16	468.40%
BAJAJ FINSERV LTD.	128.8	39.2	37.35	176.25	85.65	73	36.99	7.09	2.23	3.18	467.25%
LIC HOUSING FINANCE LTD	75.1	138	67.2	100.7	80.15	76	51.32	4.63	2.39	1.94	461.15%
ASHOK LEYLAND LTD	82.5	71.75	84.9	195.2	21.65	85	48.24	4.59	2.01	2.28	456.00%
ESCORTS KUBOTA LIMITED	106.2	55.2	117.75	158.8	7.95	84	47.62	4.97	2.35	2.11	445.90%

BALRAMPUR CHINI MILLS LTD	14.35	136.85	125.8	127.1	32.4	80	50	4.77	2.39	2.00	436.50%
DALMIA BHARAT LIMITED	**0**	**0**	46.1	231	155.5	46	56.52	4.93	1.91	2.58	432.60%
MANAPPURAM FINANCE LTD	16.25	169.1	-13.85	110.2	148.8	82	46.34	5.03	2.24	2.25	430.50%
TATA CONSUMER PRODUCT LTD	53.2	-8.45	74.3	235.85	75.1	68	45.59	5.82	2.2	2.65	430.00%
DEEPAK NITRITE LTD	97.75	17.25	68.3	112.05	132.65	84	51.19	4.76	2.35	2.03	428.00%
HINDALCO INDUSTRIES LTD	77.45	17.55	-18.45	220.6	128.4	79	46.84	4.84	2.05	2.36	425.55%
SRF LTD	72.5	77.05	-27.45	168.05	133.55	71	45.07	6.08	2.38	2.55	423.70%
TATA STEEL LIMITED	39.7	40.45	8.35	221.1	105.6	74	43.24	6.03	2.19	2.75	415.20%
FEDERAL BANK LTD	115.9	68.3	34.4	176.3	16.65	83	44.58	4.87	1.93	2.52	411.55%
MAHINDRA & MAHINDRA LTD	6	36.35	75.35	220.35	73	75	44	5.31	2.26	2.35	411.05%
BALKRISHNA IND. LTD	148.45	159.3	45.15	75.95	-21.25	78	44.87	5.1	2.11	2.42	407.60%
JK CEMENT LIMITED	101.25	81.45	-22.7	108.9	125.8	67	52.24	5.04	2.31	2.18	394.70%
COAL INDIA LTD	10	82.1	80.35	119.2	102.2	63	49.21	4.95	2.22	2.23	393.85%
MINDTREE LIMITED	-9.35	107.5	54.1	110.25	128.95	66	42.42	6.73	2.63	2.56	391.45%
INTERGLOBE AVIATION LTD	3.8	29	112.85	130.6	111	83	44.58	4.89	2.24	2.18	387.25%
GMR INFRASTRUCTURE LTD.	55.1	133.7	14.4	27.25	154	84	46.43	4.76	2.47	1.93	384.45%
TATA CHEMICALS LTD	21.1	11.8	56.75	246	44.3	85	43.53	4.54	2.04	2.23	379.95%
POWER FIN CORP LTD.	46.5	63.05	172.4	70.3	27.05	79	44.3	4.99	2.14	2.33	379.30%
GUJARAT GAS LIMITED	117.65	-52.3	124.95	114.9	73.8	73	49.32	4.86	2.3	2.11	379.00%
M&M FIN. SERVICES LTD	-24.45	38.5	49.9	247.85	63.05	86	40.7	5.14	2.13	2.41	374.85%
OIL AND NATURAL GAS CORP.	70.5	50.1	12.4	171.25	65.1	70	47.14	4.7	2.02	2.33	369.35%
ASTRAL LIMITED	159.25	24.65	83.3	78.4	19.15	80	46.25	4.49	1.99	2.26	364.75%
BERGER PAINTS (I) LTD	-14.5	75.2	132.75	120.95	49	69	53.62	4.23	2.3	1.84	363.40%
BRITANNIA INDUSTRIES LTD	60	46.9	116.35	88.8	48.35	60	51.67	4.58	2.48	1.85	360.40%
INDIAMART INTERMESH LTD	**0**	**0**	153.55	156.4	43.5	43	44.19	6.85	2.54	2.70	353.45%
HINDUSTAN UNILEVER LTD	-6.2	67.05	54.05	126	109	58	55.17	4.42	2.41	1.83	349.90%
JUBILANT FOODWORKS LTD	112.75	60.8	81.3	104.35	-9.5	71	42.25	5.71	1.98	2.88	349.70%
WIPRO LTD	89	-26.3	118.95	85.7	78.85	65	46.15	5.07	2.07	2.45	346.20%
TVS MOTOR COMPANY LTD	86.3	69.75	8.05	102.55	71.5	76	47.37	4.54	2.5	1.82	338.15%
INDIAN OIL CORP LTD	110.05	-52.2	64.05	108.75	103.7	73	45.21	4.84	2.31	2.10	334.35%
TATA COMMUNICATIONS LTD	48.5	-78.55	62.25	322.1	-22.25	80	41.25	5.42	2.45	2.21	332.05%
VEDANTA LIMITED	52.35	-30.15	-8.35	241.15	75.25	80	38.75	6.27	2.08	3.01	330.25%
L&T INFOTECH LIMITED	-36.05	62.85	34.95	177.5	82.5	69	40.58	6.09	2.15	2.83	321.75%
MULTI COMMODITY EXCHANGE	91.9	51.8	-6.3	88	92	84	48.81	3.95	2.04	1.94	317.40%
MUTHOOT FINANCE LIMITED	51.2	88.1	8	90.55	79.15	85	48.24	4.08	2.14	1.91	317.00%
AARTI INDUSTRIES LTD	6.2	102.7	48.45	119.2	37.55	76	47.37	4.76	2.35	2.03	314.10%
UNITED SPIRITS LIMITED	105.35	105.8	-42.25	92.6	50.05	81	46.91	4.76	2.36	2.02	311.55%
GRANULES INDIA LIMITED	24.85	184.3	-8.6	166.15	-56.45	91	41.76	4.86	2.17	2.24	310.25%
INDRAPRASTHA GAS LTD	70.3	92.85	26.3	130.05	-15.4	77	46.75	4.26	2.02	2.11	304.10%
LUPIN LIMITED	-42.5	53.5	88.95	190.6	4.4	79	44.3	4.49	2.24	2.00	294.95%
TORRENT POWER LTD	82.95	-3.15	20	45.45	148.85	77	45.45	4.28	2.15	1.99	294.10%
HONEYWELL AUTOMATION IND	88.7	118.7	-60.4	76.4	67.95	74	44.59	5.03	2.37	2.12	291.35%
CHAMBAL FERTILIZERS LTD	47.8	78.6	16.55	117.5	23.2	81	50.62	4.05	2.13	1.90	283.65%
APOLLO TYRES LTD	65.2	-61.1	109.65	252.4	-84.4	88	39.77	4.52	2.13	2.12	281.75%
ICICI BANK LTD.	19.95	111.75	9.55	84.55	52.95	75	50.67	4.43	2.51	1.76	278.75%
ICICI PRU LIFE INS CO LTD	17.75	97.2	62.9	21.35	78.4	72	43.06	4.61	2.05	2.25	277.60%
PAGE INDUSTRIES LTD	36.9	186.5	74.2	10.8	-33.3	78	43.59	4.88	2.22	2.20	275.10%
COFORGE LIMITED	-63.5	10.05	-54.85	245.75	135.4	88	40.91	4.98	2.22	2.24	272.85%
BATA INDIA LTD	89.35	95.55	89.75	-39.65	36.7	76	42.11	4.64	2.16	2.15	271.70%
HDFC AMC LIMITED	**0**	49.9	149.95	16.35	52.5	53	45.28	5.06	2.3	2.20	268.70%
NTPC LTD	-57	74	97.55	82.95	70.85	68	48.53	4.09	2.4	1.70	268.35%
BOSCH LIMITED	-12.8	45.5	-31.3	163.65	103	79	45.57	3.97	2.21	1.80	268.05%
THE INDIA CEMENTS LIMITED	63.5	11.75	117.85	39.35	34.95	96	47.92	3.61	2.03	1.78	267.40%
ABB INDIA LIMITED	-23.8	104.5	66.75	84.35	34.7	69	44.93	4.96	2.05	2.42	266.50%
ABBOTT INDIA LIMITED	11	68.05	60.9	57.75	66.45	70	54.29	3.87	2.43	1.59	264.15%
BHARTI AIRTEL LIMITED	28.3	145.6	-81.7	138.85	30.25	77	42.86	4.67	2.3	2.03	261.30%
TRENT LTD	6.85	-19.4	37.1	137.5	96.7	79	44.3	4.3	2.31	1.86	258.75%
CHOLAMANDALAM IN & FIN CO	-48.85	13.8	38.4	247.85	6.8	89	40.45	4.53	2	2.27	258.00%
HCL TECHNOLOGIES LTD	73.05	21.55	4.3	47.75	111.25	67	49.25	4.14	2.47	1.68	257.90%
GRASIM INDUSTRIES LTD	90.95	-26.9	81.3	113.2	-0.9	75	42.67	5.03	2.27	2.22	257.65%
APOLLO HOSPITALS ENTER. L	39.95	33.05	15.25	83.1	85.85	87	40.23	4.86	2.19	2.22	257.20%
ADITYA BIRLA FASHION & RT	9.95	17.85	-42.6	131.85	136.4	84	44.05	4.23	2.26	1.87	253.45%
SUN TV NETWORK LIMITED	65.35	-32.6	122.8	128.85	-31.4	86	43.02	4.72	2.34	2.02	253.00%
ADANI PORT & SEZ LTD	-47.25	29.9	71.1	180	15.45	79	45.57	4.53	2.53	1.79	249.20%
INDIAN ENERGY EXC LTD	-25.05	-28	-42.6	61.75	279.1	69	47.83	4.41	2.31	1.91	245.20%
POLYCAB INDIA LIMITED	**0**	**0**	107.05	122.9	13.9	46	43.48	5.53	2.09	2.65	243.85%
TATA CONSULTANCY SERV LT	81.25	74.4	70.2	34.4	-17	72	50	4.26	2.57	1.66	243.25%
INDUS TOWERS LIMITED	121.2	-123.1	43.25	150	51.1	81	45.68	4.07	2.35	1.73	242.45%
HERO MOTOCORP LIMITED	83.4	50.7	23.1	42.55	29.15	76	48.68	3.52	2.16	1.63	228.90%

UPL LIMITED	-17.8	32.25	36.15	163.25	12.05	85	45.88	3.92	2.25	1.74	225.90%
GODREJ CONSUMER PRODUCTS	-86.2	74.4	38.55	79.3	110.55	76	44.74	4.43	2.5	1.77	216.60%
DR. REDDY S LABORATORIES	12.3	11.5	-18.7	145.75	64.55	77	41.56	4.46	2.14	2.08	215.40%
BHARAT FORGE LTD	78.05	18.1	-50.55	199.8	-32.1	86	43.02	4.28	2.21	1.94	213.30%
SHREE CEMENT LIMITED	-4.7	106.9	-20.1	30.7	97.65	76	46.05	4.39	2.25	1.95	210.45%
ZYDUS LIFESCIENCES LTD	-52.2	-24.45	107.9	70.9	95.8	84	45.24	3.72	2.33	1.60	197.95%
WHIRLPOOL OF INDIA LTD	6.75	-7.6	117.4	63.25	27.9	79	41.77	3.98	2.2	1.81	207.70%
THE INDIAN HOTELS CO LTD	-42.6	-14.65	-46.75	156.6	153.2	84	35.71	5.42	2.21	2.45	205.80%
HAVELLS INDIA LIMITED	59.3	-22.9	19.3	94.7	48.3	81	40.74	4.61	2.26	2.04	198.70%
L&T TECHNOLOGY SER LTD	42.05	61.75	-16.75	110.3	-9	79	41.77	4.5	2.17	2.07	188.35%
MARUTI SUZUKI INDIA LTD	7	11	68.65	114.9	-15.9	79	46.84	3.91	2.43	1.61	185.65%
ASIAN PAINTS LIMITED	-19.35	46.6	92.6	45.5	16.4	72	47.22	3.95	2.37	1.67	181.75%
ALKEM LABORATORIES LTD	25.6	64.85	-36.5	94.8	31.9	74	47.3	3.87	2.34	1.65	180.65%
LARSEN & TOUBRO LTD	38.4	-5.35	41.2	104.5	0.8	71	45.07	4.78	2.44	1.96	179.55%
INFOSYS LIMITED	65.05	-2.35	-7.15	136.1	-19.75	69	42.03	4.32	2.23	1.94	171.90%
SIEMENS LTD	-42.9	-58.9	146.6	108.25	15.7	81	44.44	3.86	2.2	1.75	168.75%
VOLTAS LTD	25.1	42.6	57.55	56.4	-21.35	81	41.98	4.41	2.26	1.95	160.30%
SBI CARDS & PAY SER LTD	**0**	**0**	**0**	67.4	91.55	21	57.14	4.74	1.74	2.72	158.95%
ORACLE FIN SERV SOFT LTD	49.75	64.65	61.8	-11.05	-9.4	71	43.66	3.98	2.04	1.95	155.75%
MAX FINANCIAL SERV LTD	-12.55	31.4	7.9	87	39.7	86	41.86	3.85	1.87	2.06	153.45%
IPCA LABORATORIES LTD	61.65	80.95	-25.15	30.65	-1.4	78	39.74	4.67	2.44	1.91	146.70%
ATUL LTD	8	-3.4	78.5	100.1	-37.3	66	40.91	5.07	2.28	2.22	145.90%
EICHER MOTORS LTD	-15.2	-16.55	42.55	183.85	-49.75	82	41.46	4.43	2.31	1.92	144.90%
CITY UNION BANK LTD	9.4	-21.9	-11.25	143	22.9	83	42.17	3.9	2.3	1.70	142.15%
JSW STEEL LIMITED	6.35	0.25	-31.5	151.25	14.7	85	36.47	5.09	2.21	2.30	141.05%
KOTAK MAHINDRA BANK LTD	6.4	111.95	-47.35	22.85	44.4	66	45.45	4.5	2.46	1.83	138.25%
TORRENT PHARMACEUTICALS L	32.4	57.4	-42.8	104.05	-15.15	75	42.67	4.01	2.22	1.81	135.90%
MRF LTD	51.6	-69.5	21.25	118.4	12.05	70	42.86	4.08	2.39	1.71	133.80%
ACC LIMITED	35	12.55	-44.8	132.4	-14.8	82	41.46	4.08	2.32	1.76	120.35%
INFO EDGE (I) LTD	30.9	12.55	-87.55	105.15	57.4	78	43.59	4.12	2.08	1.98	118.45%
CUMMINS INDIA LTD	-55.55	41.1	-42.15	77.3	97.6	90	38.89	4.61	2.36	1.95	118.30%
COROMANDEL INTERNTL LTD	-79.1	-31.6	95.8	73.55	59.2	81	40.74	4.13	2.19	1.89	117.85%
DIVI S LABORATORIES LTD	156.35	-20.2	-140.75	41.85	77.4	89	35.96	4.6	2.29	2.01	114.65%
HDFC BANK LTD	10	30.6	-21.15	47.95	44.55	75	42.67	3.87	2.35	1.65	111.95%
SUN PHARMACEUTICAL IND L	9.5	59.35	-60.4	48.85	51.25	83	40.96	4.3	2.37	1.81	108.55%
ULTRATECH CEMENT LIMITED	149.15	-84	11	49.5	-17.35	83	44.58	4.02	2.45	1.64	108.30%
SYNGENE INTERNATIONAL LTD	99.85	-54.9	-99.6	165	-4.1	77	37.66	4.69	2.4	1.95	106.25%
BIOCON LIMITED	37.3	-73.8	1.45	100.55	23.4	90	44.44	3.48	2.25	1.55	88.90%
DR. LAL PATH LABS LTD	-25.8	-5.85	-7.85	-8.9	131.75	81	38.27	4.08	2.2	1.85	83.35%
AMARA RAJA BATTERIES LTD	-51.3	61.85	0.6	135.95	-65.5	79	37.97	4.68	2.38	1.97	81.60%
EXIDE INDUSTRIES LTD	-33.9	-4.15	18.25	75	25.6	83	38.55	4.08	2.39	1.71	80.80%
POWER GRID CORP LTD	-4.35	-70.75	14.85	109.05	29	71	45.07	3.5	2.29	1.53	77.80%
MAHANAGAR GAS LTD	-25.2	-45.7	48.45	163.15	-77.2	77	32.47	4.84	2.15	2.25	63.50%
HDFC LTD	-92.35	20.1	78.7	86.55	-36.95	75	42.67	4.16	2.62	1.59	56.05%
GAIL (INDIA) LTD	22.25	-111.1	-29.1	149.95	23.7	89	38.2	4.22	2.39	1.77	55.70%
UNITED BREWERIES LTD	-71.45	165.8	-57.65	28.45	-9.8	87	43.68	3.72	2.44	1.52	55.35%
BAJAJ AUTO LIMITED	-27.3	32.2	-23	2.85	46.4	78	39.74	3.78	2.23	1.70	31.15%
OBEROI REALTY LIMITED	-94.9	42.8	-27.2	87.2	13.1	97	41.24	3.51	2.19	1.60	21.00%
DABUR INDIA LTD	52.55	107.95	-68.45	-42.65	-31.65	74	37.84	3.97	2.38	1.67	17.75%
PIDILITE INDUSTRIES LTD	-29.8	-8.9	26.4	21.9	7.7	84	39.29	3.86	2.29	1.69	17.30%
MPHASIS LIMITED	14.95	18.15	-50.65	36.05	-2.65	77	36.36	4.96	2.46	2.02	15.85%
TECH MAHINDRA LIMITED	-39.75	-117.25	72.1	92.45	-14.9	81	32.1	5.19	2.42	2.14	-7.35%
AXIS BANK LIMITED	-183.05	94.35	-26.75	119.9	-14.45	89	38.2	4.08	2.34	1.74	-10.00%
NESTLE INDIA LIMITED	-102.8	102.4	37.3	16	-63.6	73	35.62	4.16	2.49	1.67	-10.70%
THE RAMCO CEMENTS LIMITED	-158.85	28.35	-24.8	98	38.7	92	35.87	3.98	2.35	1.69	-18.60%
AMBUJA CEMENTS LTD	-71.6	20.6	-16.05	7.65	24.5	92	41.3	3.49	2.36	1.48	-34.90%
GUJARAT STATE PETRO LTD	4.9	21.5	-113.8	33.5	16.95	94	35.11	3.92	2.22	1.77	-36.95%
CROMPT GREA CON ELEC LTD	-100.9	37.7	-10.95	11.25	20.85	82	32.93	4.6	2.33	1.97	-42.05%
MARICO LIMITED	-12.7	37.2	-31.35	12.4	-54.1	84	38.1	3.32	2.38	1.39	-48.55%
CONTAINER CORP OF IND LTD	-108.85	-46.3	48.3	75.9	-19.3	90	36.67	4.26	2.37	1.80	-50.25%
CIPLA LTD	-123.45	-14	5.55	82.95	-6.2	85	32.94	4.34	2.34	1.85	-55.15%
COLGATE PALMOLIVE LTD	-94.5	112	0.5	-44.5	-37.05	71	40.85	3.68	2.54	1.45	-63.55%
HDFC LIFE INS CO LTD	**0**	-19.2	-0.2	12.1	-83.85	68	33.82	4.13	2.34	1.76	-91.15%
SBI LIFE INSURANCE CO LTD	-28.45	-67.7	12.9	75.3	-86.9	72	31.94	4.4	2.44	1.80	-94.85%
PI INDUSTRIES LTD	-56.3	-54.5	-32.2	83.8	-61.2	89	28.09	4.7	2.17	2.17	-120.40%
PETRONET LNG LIMITED	-55.8	-66.45	-42.45	89.3	-55.4	87	33.33	3.55	2.23	1.59	-130.80%
ICICI LOMBARD GIC LIMITED	-0.9	-173.2	45.4	-49.6	42.25	73	31.51	3.78	2.17	1.74	-136.05%

Table 4.5 Definitions

S.No	Description	Formula
Total trades	Total number of trades taken in the particular stock for the period of 5 years i.e. 2017 to 2021.	Total Number of Trades
Win Rate	Depicts the percentage of Trades that ended up in Profits.	$\frac{\text{Total Winning Trades x 100}}{\text{Total Trades}}$
Average Profit in Percentage	Average of all the profits generated in the winning trades.	$\frac{\sum \text{Returns}_{\text{Profitable Trades}} \text{ x 100}}{\text{Total No. of Profitable Trades}}$
Average Loss in Percentage	Average of all the losses generated in the losing trades.	$\frac{\sum \text{Returns}_{\text{Losing Trades}} \text{ x 100}}{\text{Total No. of Losing Trades}}$
Average Risk : Reward	Average of all the Risk to Reward ratios for all the trades executed in all 194 stocks.	$\frac{\text{Average Profit}}{\text{Average Loss}}$
Total Profit	Sum of all profits generated in the particular stock throughout the course of 5 years.	$\sum \text{Returns}$

4.2.1.2 - Prediction of Closing Prices using LSTM

TCS

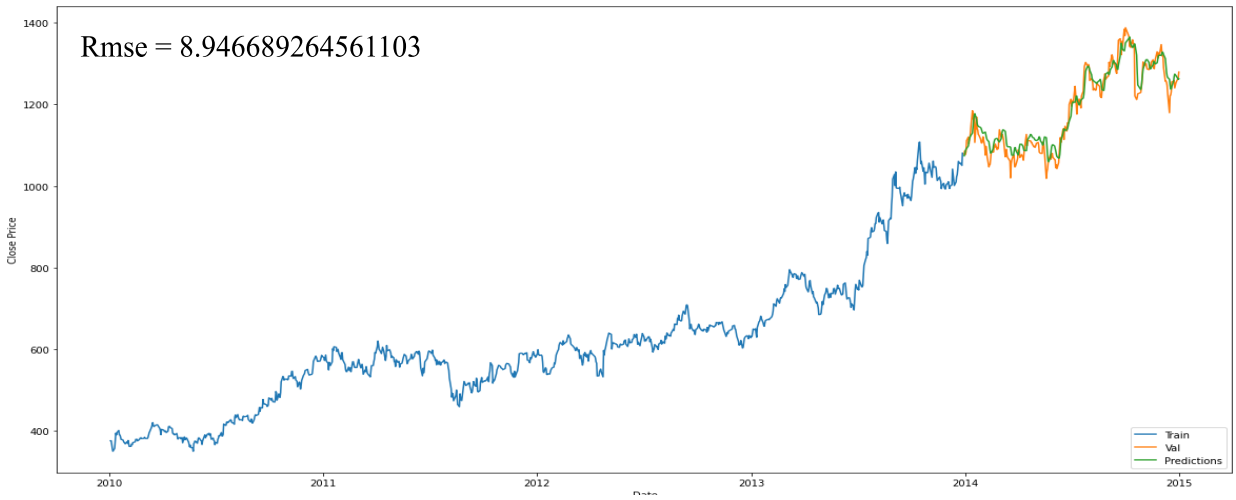

Fig. 4. 12 TCS Closing Price

WIPRO

Fig. 4. 13 WIPRO Closing Price

ICICIBANK

Fig. 4. 14 ICICIBANK Closing Price

NESTLEIND

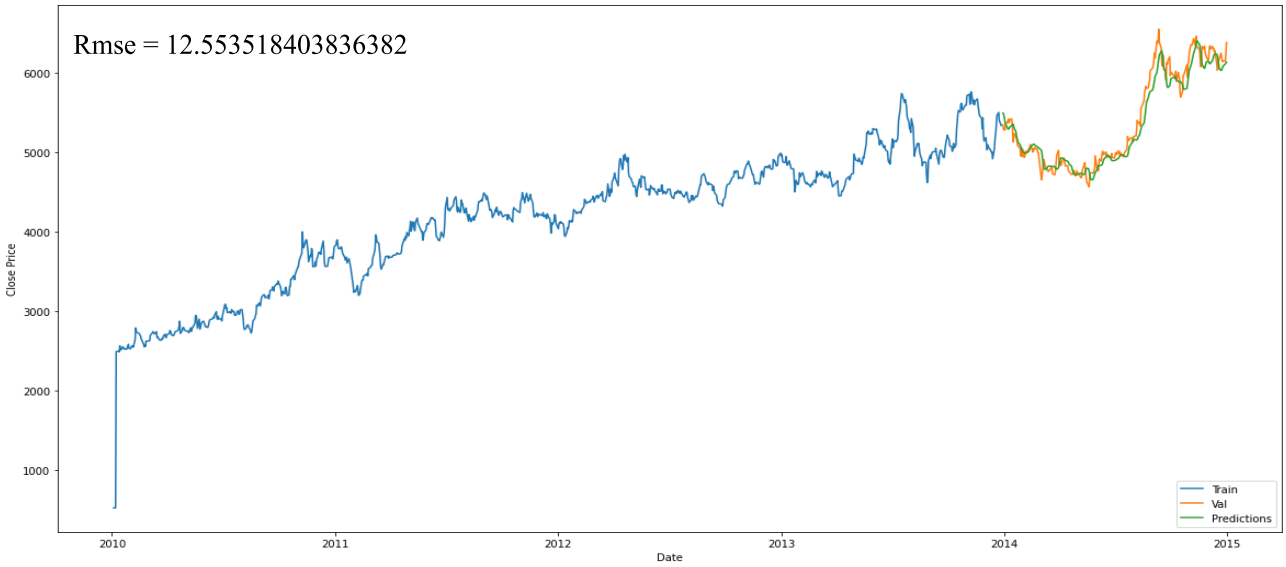

Fig. 4. 15 NESTLEIND Closing Price

RELIANCE

Fig. 4. 16 RELIANCE Closing Price

Chapter 5

Conclusion and Future Works

From the above results, it is clear the strategy is very much profitable in itself and is totally ready to run standalone. However, in the next phases of the project, we will be trying to integrate a fully backtested ML model with our current system in an attempt to further enhance the win rate and win size by trying to eliminate low-quality trades.

We would be further hypertuning the ML model and test the performance of the multivariate ML model by playing with certain parameters such as candle time frames, switching between the candle data (such as replacing close with high or low and so on), trying to figure out how long ahead in future is it able to predict with good accuracy. We need the ML model to predict the stock prices with an error margin of less than 1% of the stock price with a probability of more than 50%. So this is what we are going to work on in the upcoming phases of the project.

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